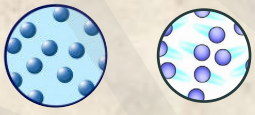
POLLUTION

Quick Revision Module [UPSC Prelims 2022] ENVIRONMENT

AIR POLLUTION

What is air pollution made of?

Gases Vs particles

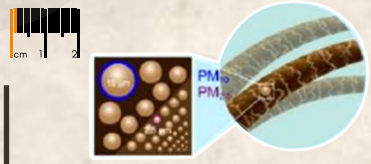


Gases vs. particles: Air pollution is anything in the atmosphere that is dangerous to people, animals, plants, or the environment as a whole. There are two major things that can pollute the air. The first is gases like ozone or sulfur dioxide. The second type of pollution is particulates-microscopic bits of solid or liquid particles that are light enough to become suspended in the atmosphere. The MAIA investigation focuses on particulate air pollution.

Size of Particulates

1 mm is equal to: 1000 micrometers

Average human hair: 70 micrometers diameter



Size of particulates: Particulate matter or PM is often grouped by the size of the individual particles. This is important because size determines how easily the particles interact with our bodies when they enter our lungs. PM is so small that it is usually measured in micrometers – one millionth of a meter. The two major size classes of PM are PM 10(particles under 10 micrometers in diameter) and PM 2.5(particles smaller than 2.5 micrometers in diameter).

Types of PM

Types of PM: PM types include black carbon, mineral dust, and tiny liquid droplets containing sulfates, nitrates, and organic carbon. Black carbon, which makes up soot, is left over after some thing burns. Dust is made of tiny bits of soil. Most sulfate and nitrate aerosols come from chemical reactions between gas molecules. Organic carbon aerosols can also form this way, or they can be directly emitted into the air.

Indoor Air Pollution
Major Sources:
- Solid Fuel Combustion
- Cigarette Smoke
- Poor ventilation
- Households Processes

Outoor Air Pollution
Major Sources:
- Major Vehicles
- Industrial Processes
- Forest Fires
- Biomass Combustion

Adverse health effect

Birth
- LBW
- IUGR
- Preterm birth
- Stillbirth
- Neural Tube Defects
- Anthropomorphic Measure reductions

Early Life:
- Asthma
- Upper Airway Irritation
- Cardiovascular Dysfunction
- Respiratory Illness
- Development
- Insulin Resistance

Adulthood:
- Stroke
- Cardiovascular Dysfunction
- DNA Damage
- Chronic Bronchitis
- Respiratory Illness

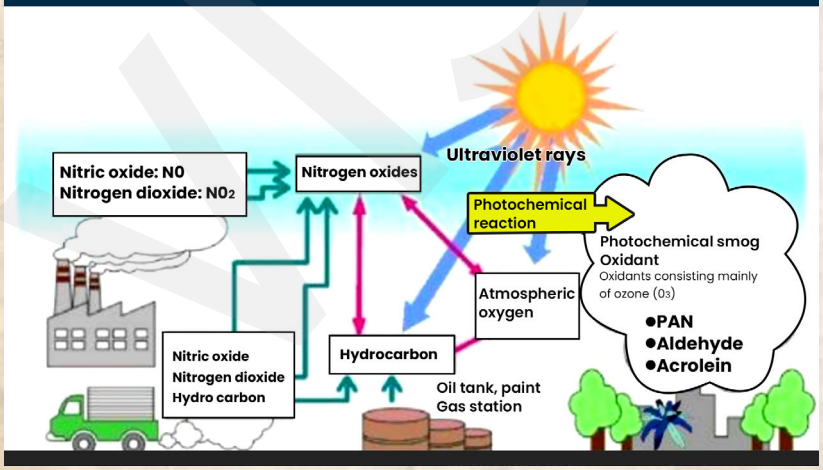
Particulate Matter (PM): from 0.001 to 500 μm in diameter.

- Particles less than 10μm float and move freely with the air current. Particles which are more than 10μm in diameter settle down. Particles less than 0.02 μm form persistent aerosols.
- PM bigger than 5 microns are likely to lodge in the nasal passage, whereas particles of about 10 microns enter into lungs easily.
- Example of PM:
  - **Dust:** fine solid particles (over 1μm in diameter)
  - **Mists:** Produced by particles of spray liquids and by condensation of vapours in air.
  - **Fumes:** Are generally obtained by the condensation of vapours during sublimation, distillation, boiling and several other chemical reactions. Generally, organic solvents, metals and metallic oxides form fume particles.
  - **Smog:** Smoke + fog.

SMOG

Classical Smog	Photochemical Smog
Occurs in cool humid climate	Occurs in warm, dry and sunny climate
Smoke + Fog + Sulphur Dioxide	VOC + Nitrogen Dioxides
Reducing Smog	Oxidizing Smog

FORMATION OF PHOTOCHEMICAL SMOG



NO_2 + UV radiation $\xrightarrow{\text{Photolysis}}$ NO + (O)...(i)

$O + O_2 \rightleftharpoons O_3$ ...(ii)

Ozone so formed oxidise NO to $NO_2 + O_2$

$NO + O_3 \longrightarrow NO_2 + O_2$ ...(iii)

$(O) + \text{Hydrocarbon} \longrightarrow RCO^{\bullet} \xrightarrow{O_2} RCO_3^{\bullet}$

$RCO_3^{\bullet} + \text{Hydrocarbons} \longrightarrow CH_2 = O,$

ketones, etc.

$RCO_3^{\bullet} + O_2 \longrightarrow RCO_2^{\bullet} = O_3$

$RCO_3^{\bullet} + NO \longrightarrow RCO_2^{\bullet} = NO_2$

$RCO_3^{\bullet} + NO_2 \longrightarrow RCO_3^{\bullet}NO_2(PAN)$

The presence of excessive O_3 along with aldehydes ketones, PAN constitute photochemical smog.

Air Pollutants and their sources:

Pollutants	Source	Harmful effects
Gaseous Pollutants		
Oxides of Carbon (CO and CO_2)	Burning of wood and coal and other fossil fuels like petroleum.	Global warming Respiratory issues
Oxides of Sulphur (SO2 and H_2S)	Power plants and refineries Volcanic eruptions When Sulphur containing fuel is burnt.	Acid rain Respiratory issues Loss of chlorophyll in plants (Chlorosis).
Oxides of Nitrogen (NO and N_2O)	Naturally (Lightning) In Automobile exhaust: (at high temperature) N_2 (g) + O_2 (g) → 2NO(g) 2NO (g) + O_2 (g) → $2NO_2$ (g)	Irritation in eyes and lungs Low productivity in plants Acid rain
Hydrocarbons (Benzene and Ethylene)	Automobiles and Petroleum industries (Incomplete combustion of fuels)	Respiratory issues Carcinogenic
Particulate Pollutants		
Suspended Particulate matter: ▪ Fly Ash ▪ Lead and other metals	Thermal power plants Construction activities metallurgical processes Automobiles exhaust	Smog (Smoke + Fog) leads to Poor visibility Breathing problems Lead interferes with the development of red blood cells Carcinogenic
Fibres (Cotton, wool)	Textiles and carpet weaving industries	Lung disorders

Difference between various indices:

SAFAR	NAAQS	
System Of Air Quality and Weather Forecasting and Research	National Ambient Air Quality Standards (NAAQS)	Air Quality Index (AQI)
Introduced by the **Ministry of Earth Sciences.**	Notified by Central Pollution Control **Board (CPCB).**	Initiated by the **Ministry of Environment Forest and Climate Change** under **Swachh Bharat Abhiyan.**
Developed indigenously by the Indian Institute of Tropical Meteorology **(IITM)**, Pune, and operationalized by India Meteorological Department **(IMD)**.	Under **The Air (Prevention and Control of Pollution) Act, 1981.**	It is a **color coded index** graded with possible health impact.
Provide **location-specific information** on air quality in **near real-time** and its **forecast 1-3 days in advance in major metropolitan** cities of India.		There are **six AQI categories,** namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe.
Pollutants monitored: PM1, PM2.5, PM10, Ozone, CO, NOx (NO, NO2), SO2, BC, Methane (CH4), Non- methane, hydrocarbons (NMHC), VOC's, Benzene and Mercury.	**Covers 12 pollutants:** Sulphur Dioxide, Nitrogen Dioxide, PM-10, PM-2.5, Ozone, Lead, Carbon Monoxide, Ammonia, Benzene, BenzoPyrene, Arsenic and Nickel.	Measure **8 major pollutants** - Particulate matter (PM 10 and PM 2.5), Nitrogen dioxide, sulphur dioxide, ozone, carbon monoxide, ammonia and lead.
Meteorological Parameters: UV Radiation, Rainfall, Temperature, Humidity, Wind speed, Wind direction, solar radiation.	NA	NA

Gothenburg Protocol: It is one of the Eight Protocols under **UNECE Convention on Long Range Transboundary Air Pollution (CLRTAP or Air convention).** It was adopted in 1999 to abate Acidification, Eutrophication and Groundlevel Ozone. The revised Protocol (2012) sets national emission ceilings (up to 2020) for **four pollutants: sulphur (SO2), nitrogen oxides (NOx), volatile organic compounds (VOCs) and ammonia (NH3).** It is also the first binding agreement to include emission reduction commitments for fine particulate matter. Also, **black carbon (or soot),** a short-lived climate pollutant is included within particulate matter for policymakingt.

Legislations to control Air Pollution:

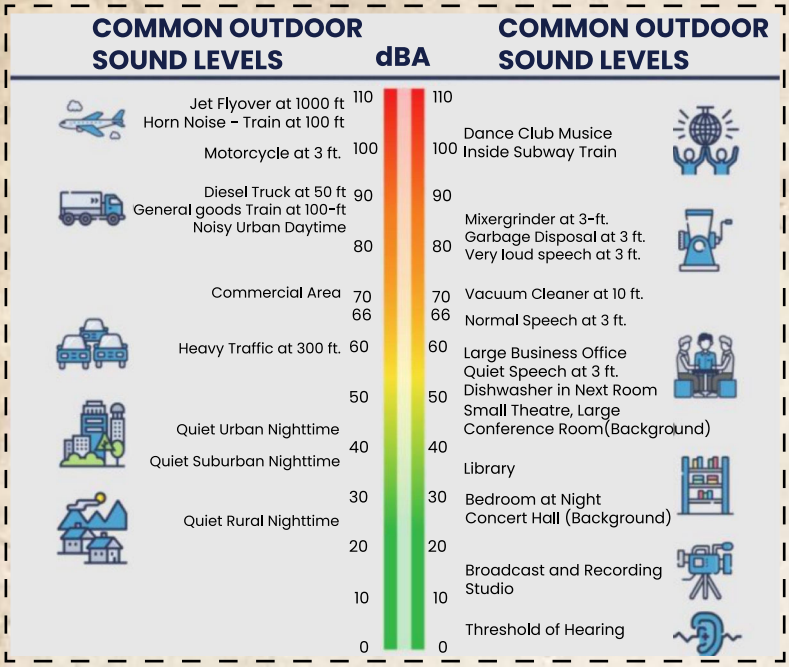
THE AIR (PREVENTION AND CONTROL OF POLLUTION) ACT, 1981: This act defines air pollutants and pollution, and provides regulations for appliances, fuels, and automobiles for preserving the quality of air. It has also conferred power to the Central Pollution Control Board (CPCB)/SPCB to act as a nodal authority to control air pollution in India.

Environment (Protection) Act,1986: It authorizes the central government to protect and improve environmental quality, control and reduce pollution from all sources (air, water, land), and prohibit or restrict the setting and /or operation of any industrial facility on environmental grounds.

Steps taken to curb Air Pollution

National clean Air programme (NCAP)	▪ The Central Government launched NCAP in 2019 under the Central Sector "Control of Pollution" Scheme as a long-term, time-bound, national level strategy to tackle the air pollution problem across the country in a comprehensive manner with targets to achieve 20 % to 30 % reduction in PM10 and PM2.5 concentrations by 2024 keeping 2017 as the base year for the comparison of concentration. ▪ 122 non-attainment cities mostly in Indo-Gangetic Plains have been identified based on ambient air quality data for the period 2014-2018. ▪ A non-attainment city is considered to have air quality worse than the National Ambient Air Quality Standards.
Bharat Stage Emission Standards (BSES)	▪ These are the legal limits on the amount of air pollutants like carbon monoxide and particulate matter that a vehicle in India can emit. ▪ These standards are targeted at making improvements in three areas i.e., emission control, fuel efficiency and engine design. ▪ India has planned to shift to BS-VI norms from BS-VI from 2020.
Carbon Emission by Thermal Power Plants (TPPS)	▪ Ministry of Environment, Forest and Climate Change had notified environmental norms to reduce emission of PM 10, SO2 and oxide of nitrogen.
Graded Response Action Plan (GRAP) enforced by EPCA	For Delhi and the NCR region, which comprises the graded measures for each source framed according to the Air Quality Index categories. For example: ▪ During 'very poor' air quality, it recommends banning diesel generators and parking fee increased by three to four times.
Focus on short-lived climate pollutants (SLCP)	▪ Like methane, HFCs, black carbon (soot), tropospheric ozone etc. SLCP mitigation has the potential to avoid up to 0.6°C of warming by mid-century while aggressive CO2 mitigation in a comparable scenario leads to less than half as much near-term reduction in warming.

NOISE POLLUTION



Regulations for Noise Pollution:

The CPCB has laid down the permissible noise levels in India for different areas.

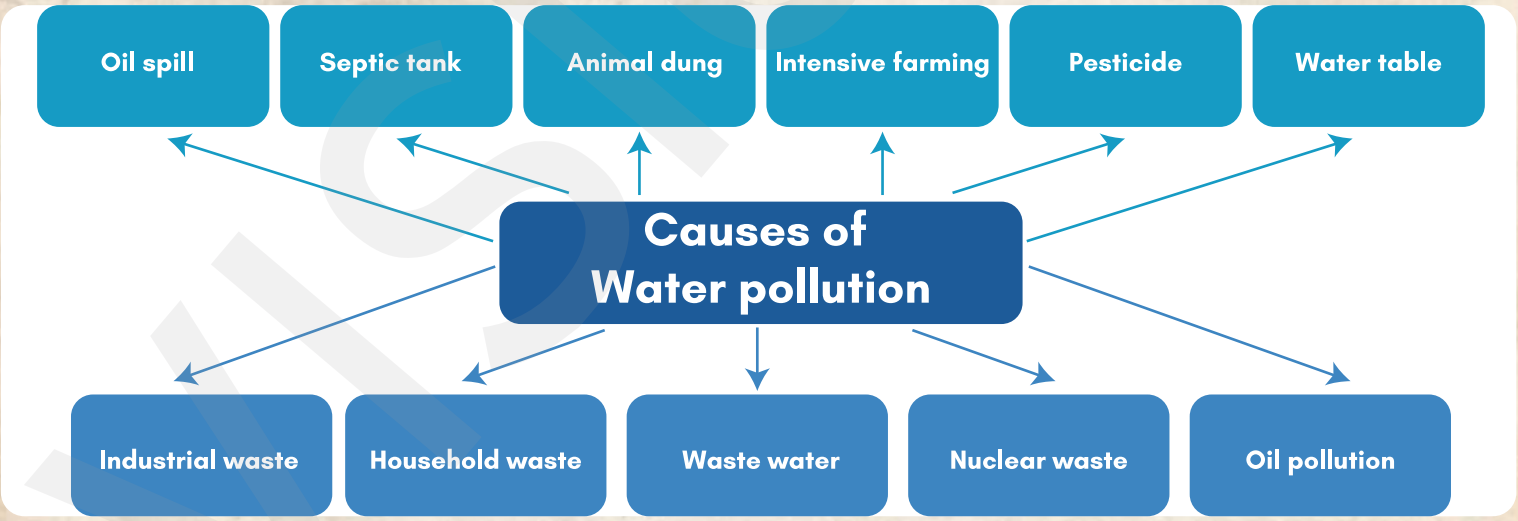
- Industrial areas: 75 dB for daytime and 70 dB at nightIndustrial areas: 75 dB for daytime and 70 dB at night
- Commercial areas: 65 dB and 55 Db during day and night respectively
- Residential areas: 55 dB and 45 dB during daytime and night respectively.

State governments have also declared **'silent zones'** i.e., areas lying within 100 meters of the premises of schools, colleges, hospitals and courts. The permissible noise limit in this zone is 50 dB during the day and 40 dB during the night.

Laws governing Noise Pollution:

Air (Prevention and Control of Pollution) Act, 1981	It includes 'Noise' as an air pollutant. **Noise emanating from industry** is to be regulated by State Pollution Control Boards / Pollution Control Committees (SPCBs / PCCs) for states / Union territories
Noise Pollution (Regulation and Control) Rules, 2000	It defines and regulates noise pollution and its sources
Environment (Protection) Rules, 1986	It prescribes noise standards for motor vehicles, air conditioners, refrigerators, diesel generators and certain types of construction equipment.

WATER POLLUTION



Central Pollution Control Board (CPCB):

- Statutory body constituted under the Water (Prevention and Control of Pollution) Act, 1974. Monitors water quality.
- Further, it was also entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981. Monitors air quality.
- It also provides technical services to the Ministry of Environment and Forests under the provisions of the Environment (Protection) Act, 1986.

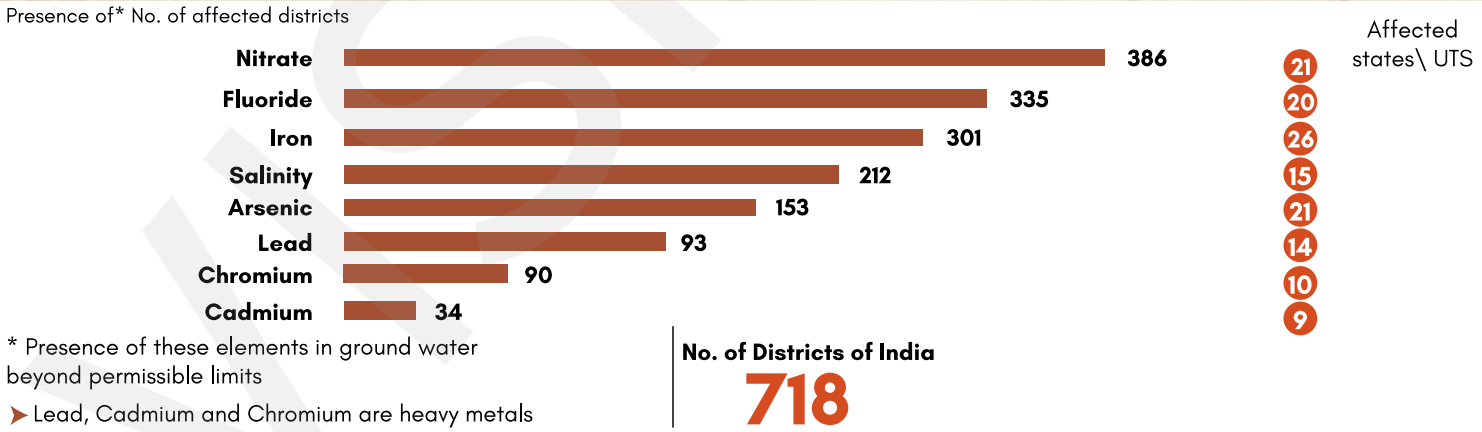
India and Stockholm Convention:

- India ratified the Convention in 2006. In 2018, the MoEFCC notified the **'Regulation of Persistent Organic Pollutants Rules'** under the provisions of Environment (Protection) Act, 1986.
- It prohibited the manufacture, trade, use, import and export of **seven chemicals** namely (i) Chlordecone, (ii) Hexabromobiphenyl, (iii) Hexabromodiphenyl ether and Heptabromodiphenylether (Commercial octa-BDE), (iv) Tetrabromodiphenyl ether and Pentabromodiphenyl ether (Commercial penta-BDE), (v) Pentachlorobenzene, (vi) Hexabromocyclododecane, and (vii) Hexachlorobutadiene, which were already listed as POPs under Stockholm Convention.
- India would be able to access the financial resources of **the Global Environmental Facility (GEF)** designated under Stockholm convention.

Ground Water Pollution

Pollutant	Permissible limit	Effects
Fluoride	Permissible limit is 1.5 mg/L.	Excess fluoride causes neuro-muscular disorders, gastro-intestinal problems, teeth deformity, hardening of bones, and skeletal fluorosis.
Arsenic	Permissible limit is 0.01 mg/L.	Chronic exposure to Arsenic causes Black foot disease. It may also cause diarrhoea, lung and skin cancer.
Nitrates	Permissible limit is 45mg/L.	Excess Nitrate in drinking water causes methemoglobinemia or blue baby Syndrome.
Iron	High concentration of Iron means >1.0 mg/L	High concentration in drinking water can lead to hemochromatosis which can lead to liver, heart and pancreatic damage.
Lead	Permissible limit is 0.01mg/L	Brain/Nervous system disorders
Cadmium	Permissible limit is 0.003mg/L	Renal tubular diseases (stones, etc.) Itai Itai disease (bone decalcification).

HEAVY METALS AT WORRYING LEVELS



* Presence of these elements in ground water beyond permissible limits

➤ Lead, Cadmium and Chromium are heavy metals

No. of Districts of India
718

REGULATION OF GW:

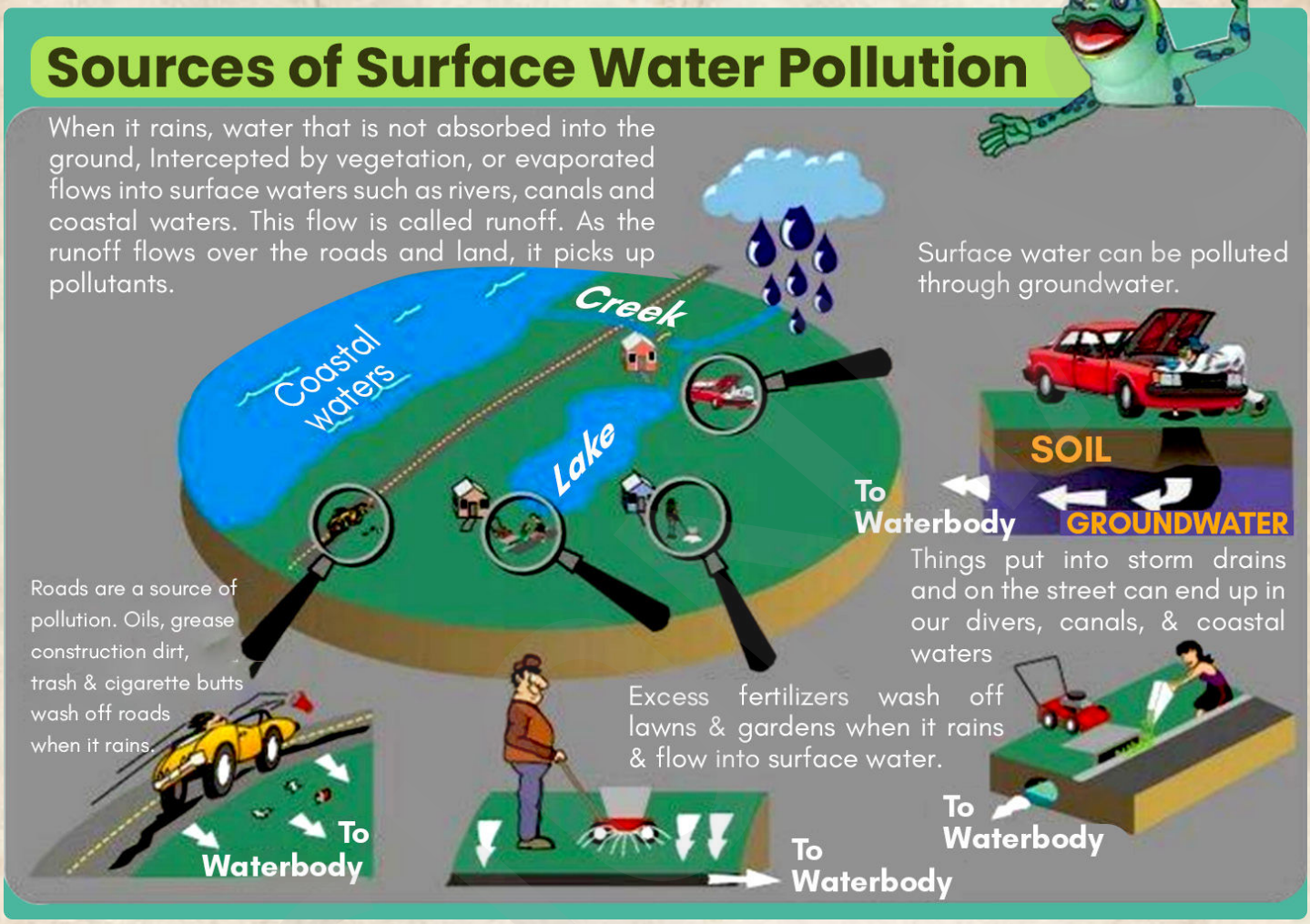
- No Central law exists. The Groundwater (Sustainable Management) Bill, 2017 is still pending.
- Water as a subject belongs to the states. However, under the Environment Protection Act 1986, the Central Ground Water Authority (CGWA) can issue guidelines for development and management of groundwater resources.
- The chemical quality of ground water is monitored once a year by the Central Ground Water Board through a network of about 15,000 observation wells located all over the country.

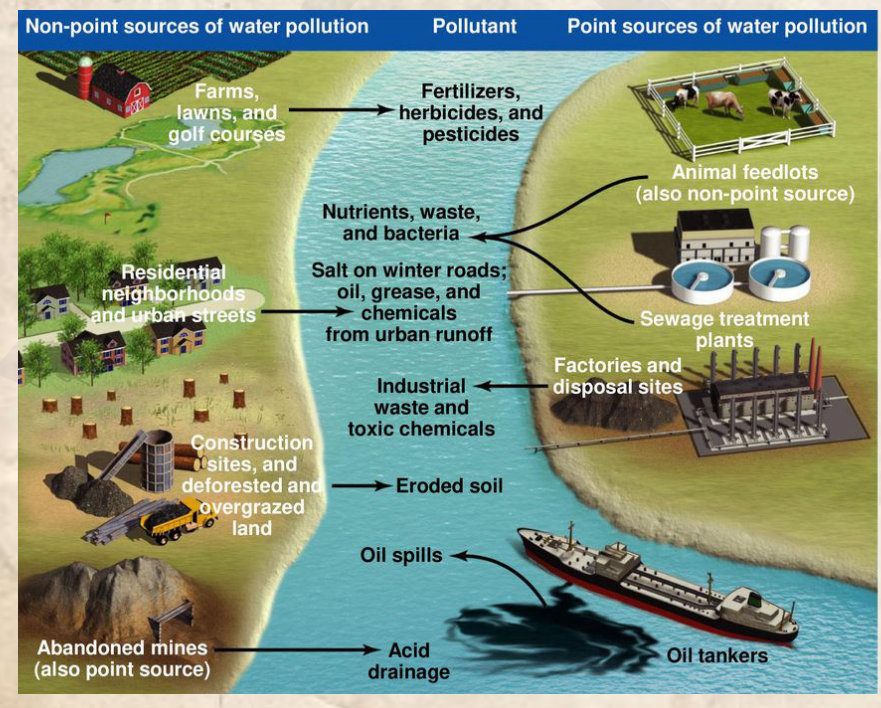
Surface Water Pollution

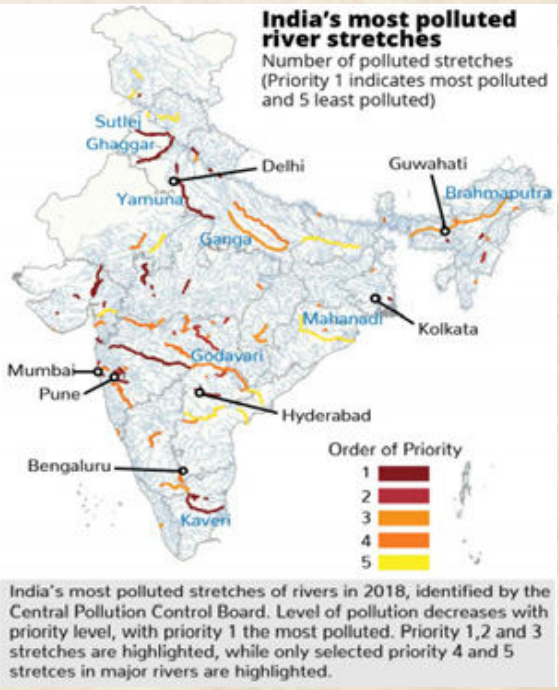
Status of Surface Water Pollution in India:

- The CPCB considers a BOD less than 3 mg/l as an indicator of a healthy river.
- As per CPCB report, 80% of India's surface water is polluted.
- It leads to poor nutrition as well as vector borne diseases such as Cholera, dysentery, jaundice, etc.

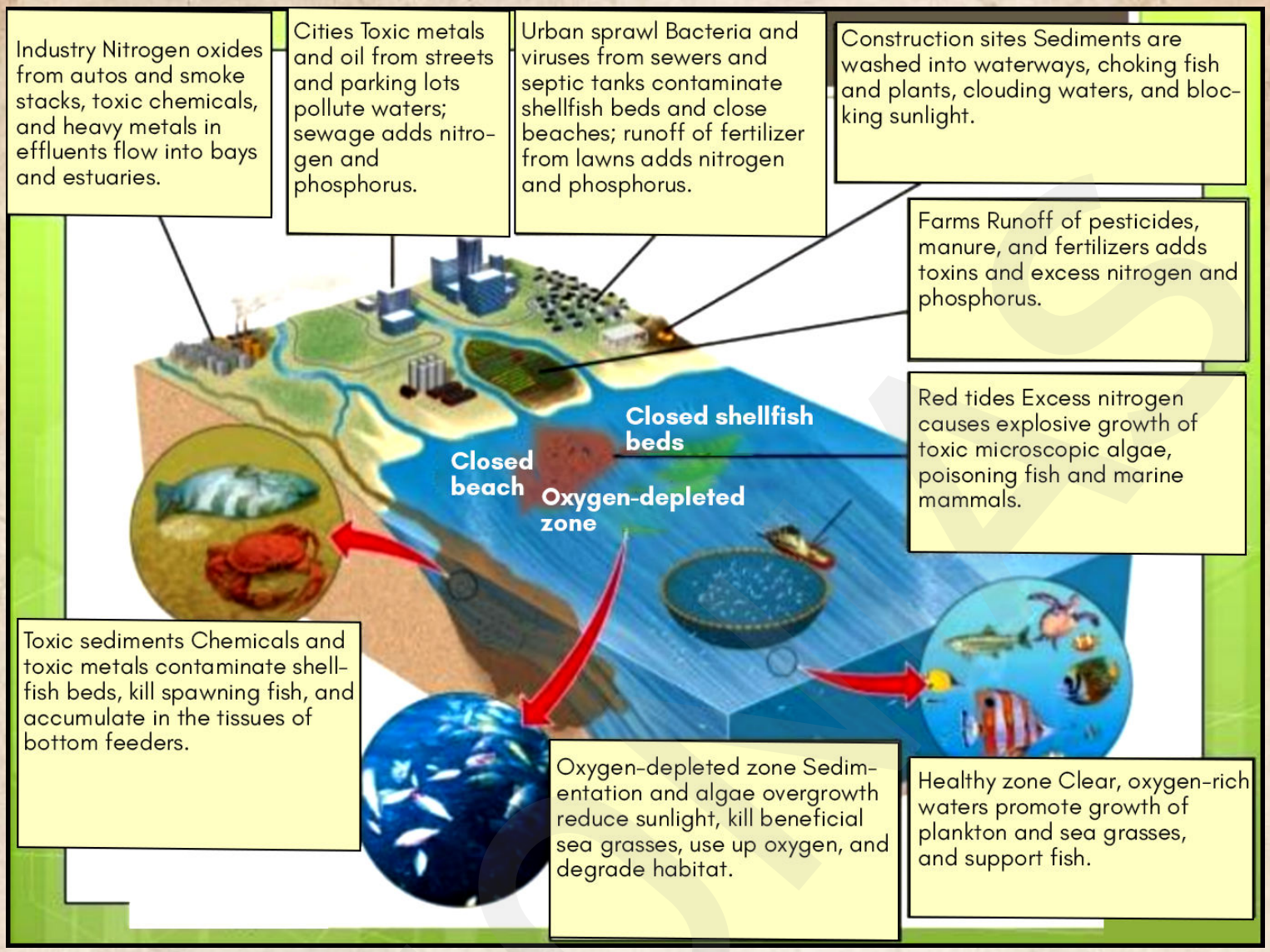
Sources of Surface Water Pollution





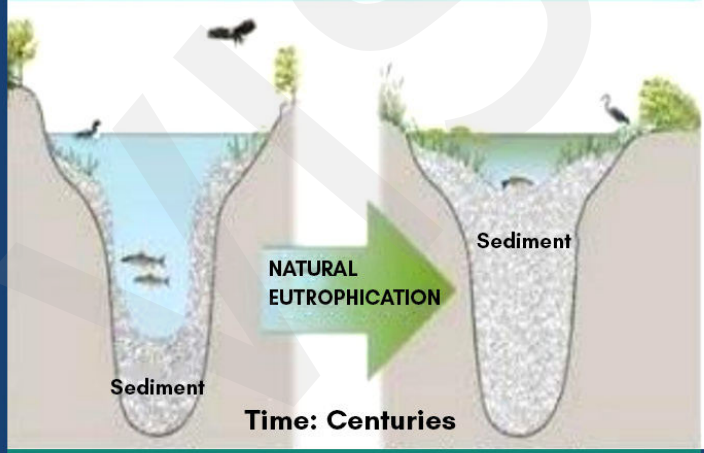


India's most polluted stretches of rivers in 2018, identified by the Central Pollution Control Board. Level of pollution decreases with priority level, with priority 1 the most polluted. Priority 1,2 and 3 stretches are highlighted, while only selected priority 4 and 5 stretces in major rivers are highlighted.



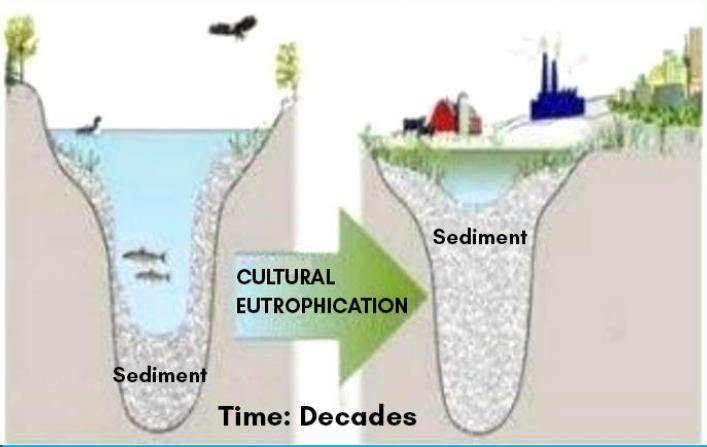
Eutrophication

Natural Eutrophication



a process that occurs as a lake or river ages over a period of hundreds or thousands of years.

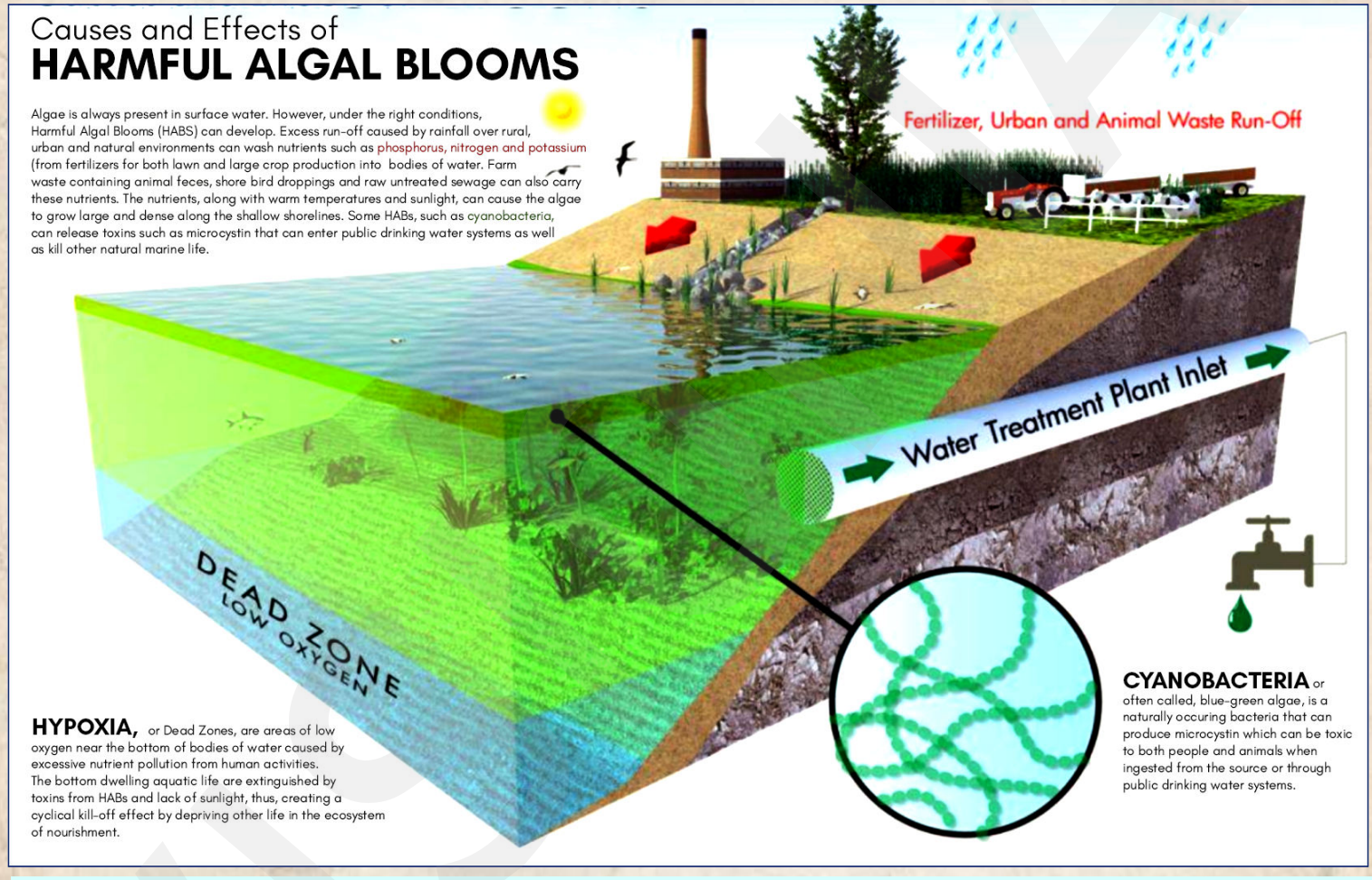
Cultural Eutrophication



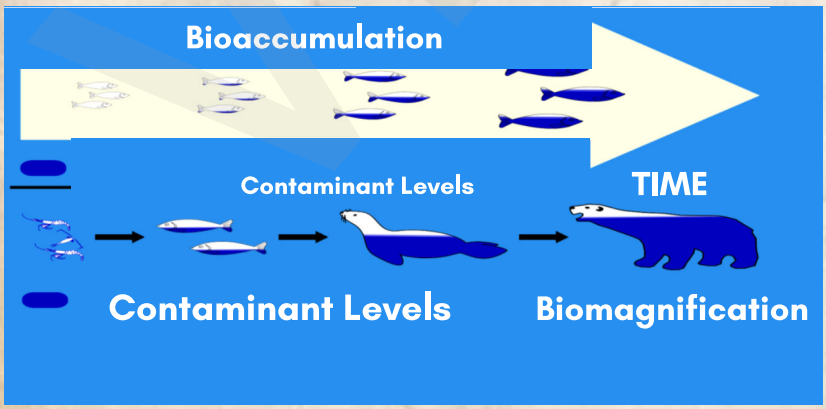
a process that occurs when humans release excessive amounts of nutrients; it shortens the rate of aging to decades.

Consequences of HAB:

- **Impacts over water quality:** Colour changes, obnoxious smell and unfit for drinking.
- **Impact over biodiversity:** Limits the penetration of light causing die-offs of plants in littoral zones and their dependent population. This increases the Biological Oxygen Demand (BOD) of water. Dissolved oxygen decreases and results into fish-kills. In worst cases, it leads to Hypoxia of water-bodies, further leading to formation of dead-zones where water can no more support life.
  - High rates of photosynthesis associated with eutrophication can deplete dissolved inorganic carbon and raise pH to extreme levels during the day. Elevated pH can in turn 'blind' organisms that rely on perception of dissolved chemical cues for their survival.
- **Impact over humans:**
  - Eating seafood contaminated by toxins from algae called **Alexandrium** can lead to paralytic shellfish poisoning, which can cause paralysis and even death.
  - The algae **Pseudo nitzschia** produces a toxin called domoic acid that can cause vomiting, diarrhoea, confusion, seizures, permanent short term memory loss, or death, when consumed at high levels.
  - Consumption may result into accumulation of toxic wastes in the human body through biological processes such as Bioaccumulation and Bio-Magnification.



In India, four regions have been identified as Algal bloom hotspots viz North Eastern Arabian Sea, Coastal waters off Kerala, Gulf of Mannar, and coastal waters of Gopalpur



Biomagnification

Biomagnification, also known as bioamplification, is the process by which **substances become more concentrated** in the bodies of consumers **as one moves up the food chain** (trophic levels).

When chemicals or pesticides are let into rivers or lakes they are consumed by aquatic organisms like fish, which in turn are consumed by large birds, animals or humans. These harmful substances become concentrated in tissues, internal organs as it moves up the food chain.

Following substances have the potential to biomagnify:

1. **Polychlorinated Biphenyls** used as insulators in transformers and fire retardants.
2. **Polynuclear aromatic hydrocarbons** which are present in petroleum products.
3. **Heavy metals** like Mercury, copper, cadmium, chromium, lead, nickel, zinc, tin (TBT or tributyltin).
4. **Cyanides** used in fishing and gold leaching

Effects of biomagnification:

1. High concentrations of DDT in some bird species caused **failure of eggs by thinning the shells.**
2. PCBs can **affect the immune system,** fertility, child development and possibly increase the risk of certain cancers.
3. **Mercury poisoning** interferes with the nervous system development in fetuses and young children.

Bioaccumulation v/s Biomagnification

- Although sometimes used interchangeably with bioaccumulation, an important distinction between the bioaccumulation and biomagnifications is that bioaccumulation occurs within a trophic level, and is the increase in concentration of a substance in certain tissues (usually in fatty tissue.) of organisms' bodies due to absorption from food and the environment.
- The longer the half-life of the substance the greater is the risk of poisoning though levels of toxins are not very high in the environment. Bioaccumulation varies between individual organisms as well as between species.
- Large, fat, long-lived individuals or species with low rates of metabolism or excretion of a chemical will bioaccumulate more than small, thin, short-lived organisms. Thus, an old lake trout may bioaccumulate much more than a young bluegill in the same lake.

Laws and Policies for Controlling Water Pollution in India

- **Water (Prevention and Control of Pollution) Act (1974):** It established Pollution Control Boards at the Central and State levels and bestowed them with powers to prevent and control water pollution and to advise governments on matters pertaining such pollution.
- **National River Conservation Plan:** Launched in 1985 with Ganga Action Plan, its main objective is to reduce the pollution load in rivers through implementation of various pollution abatement works, thereby improving their water quality.
- **National Water Monitoring Programme (NWMP):** Under it, CPCB monitors the water quality of both surface and ground water through a network of monitoring stations in the country.
- **Namami Gange programme** for effective abatement of pollution, conservation and rejuvenation of National River Ganga.
- **National Water Policy, 2012:** One of its important provision includes conservation of river corridors and water bodies and ensuring that the industrial effluents, local cesspools, residues of fertilisers and chemicals etc. do not reach the water source.
- In **budget 2019-2020,** Government unveiled vision for 2030 which includes clean rivers, with safe drinking water to all Indians, sustaining and nourishing life and efficient use of water in irrigation using micro-irrigation techniques.
- To assess the efficacy of river cleaning programmes, the CPCB has been ordered by NGT to launch a nationwide programme on biodiversity monitoring and indexing of the rivers. NGT has also directed MoEFCCC to consider giving environmental awards to institutions and states that comply with orders and ensure a reduction in pollution.

MARINE POLLUTION

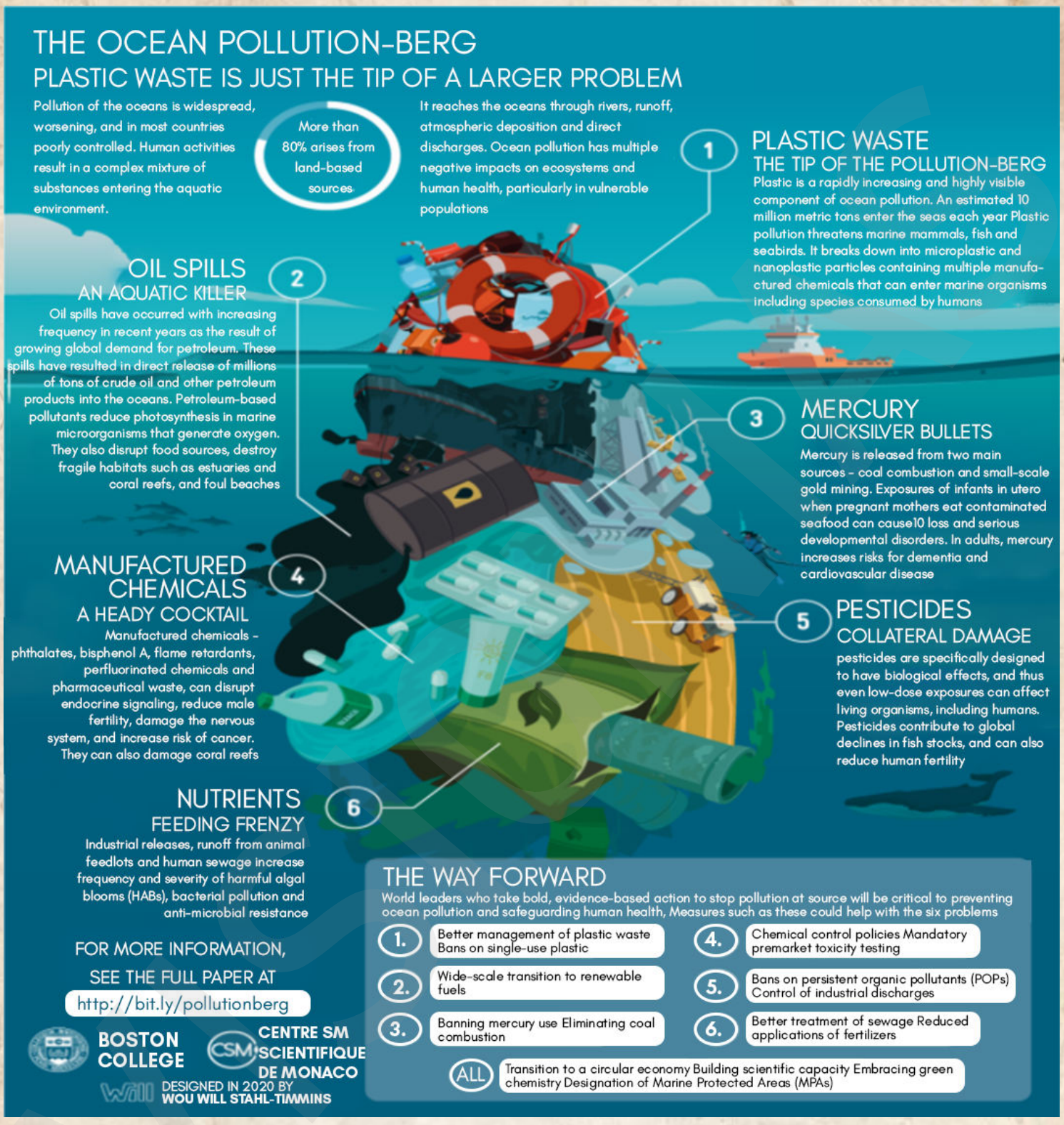
THE OCEAN POLLUTION-BERG

PLASTIC WASTE IS JUST THE TIP OF A LARGER PROBLEM

Pollution of the oceans is widespread, worsening, and in most countries poorly controlled. Human activities result in a complex mixture of substances entering the aquatic environment.

More than 80% arises from land-based sources

It reaches the oceans through rivers, runoff, atmospheric deposition and direct discharges. Ocean pollution has multiple negative impacts on ecosystems and human health, particularly in vulnerable populations



1 PLASTIC WASTE
THE TIP OF THE POLLUTION-BERG

Plastic is a rapidly increasing and highly visible component of ocean pollution. An estimated 10 million metric tons enter the seas each year Plastic pollution threatens marine mammals, fish and seabirds. It breaks down into microplastic and nanoplastic particles containing multiple manufactured chemicals that can enter marine organisms including species consumed by humans

2 OIL SPILLS
AN AQUATIC KILLER

Oil spills have occurred with increasing frequency in recent years as the result of growing global demand for petroleum. These spills have resulted in direct release of millions of tons of crude oil and other petroleum products into the oceans. Petroleum-based pollutants reduce photosynthesis in marine microorganisms that generate oxygen. They also disrupt food sources, destroy fragile habitats such as estuaries and coral reefs, and foul beaches

3 MERCURY
QUICKSILVER BULLETS

Mercury is released from two main sources – coal combustion and small-scale gold mining. Exposures of infants in utero when pregnant mothers eat contaminated seafood can cause10 loss and serious developmental disorders. In adults, mercury increases risks for dementia and cardiovascular disease

4 MANUFACTURED CHEMICALS
A HEADY COCKTAIL

Manufactured chemicals – phthalates, bisphenol A, flame retardants, perfluorinated chemicals and pharmaceutical waste, can disrupt endocrine signaling, reduce male fertility, damage the nervous system, and increase risk of cancer. They can also damage coral reefs

5 PESTICIDES
COLLATERAL DAMAGE

pesticides are specifically designed to have biological effects, and thus even low-dose exposures can affect living organisms, including humans. Pesticides contribute to global declines in fish stocks, and can also reduce human fertility

6 NUTRIENTS
FEEDING FRENZY

Industrial releases, runoff from animal feedlots and human sewage increase frequency and severity of harmful algal blooms (HABs), bacterial pollution and anti-microbial resistance

FOR MORE INFORMATION, SEE THE FULL PAPER AT
http://bit.ly/pollutionberg

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DESIGNED IN 2020 BY WOU WILL STAHL-TIMMINS

THE WAY FORWARD

World leaders who take bold, evidence-based action to stop pollution at source will be critical to preventing ocean pollution and safeguarding human health, Measures such as these could help with the six problems

1. Better management of plastic waste Bans on single-use plastic
2. Wide-scale transition to renewable fuels
3. Banning mercury use Eliminating coal combustion
4. Chemical control policies Mandatory premarket toxicity testing
5. Bans on persistent organic pollutants (POPs) Control of industrial discharges
6. Better treatment of sewage Reduced applications of fertilizers

ALL Transition to a circular economy Building scientific capacity Embracing green chemistry Designation of Marine Protected Areas (MPAs)

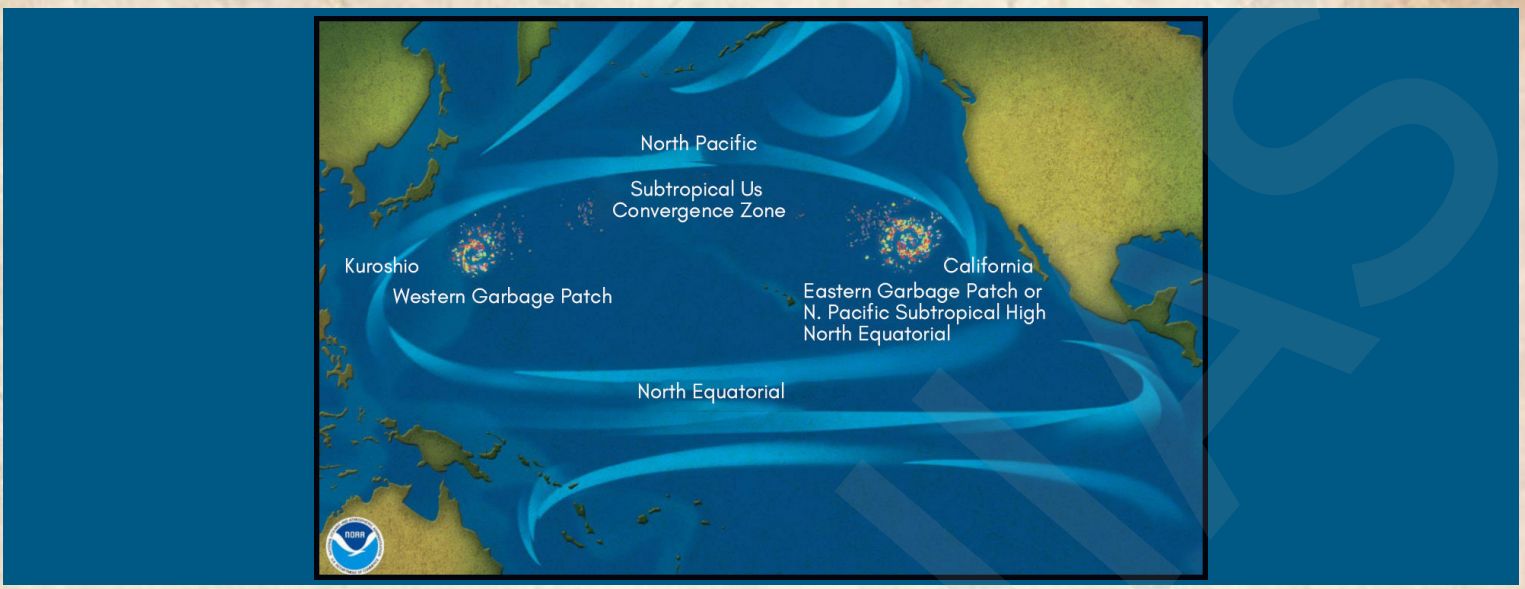
Marine Pollution regulations in India

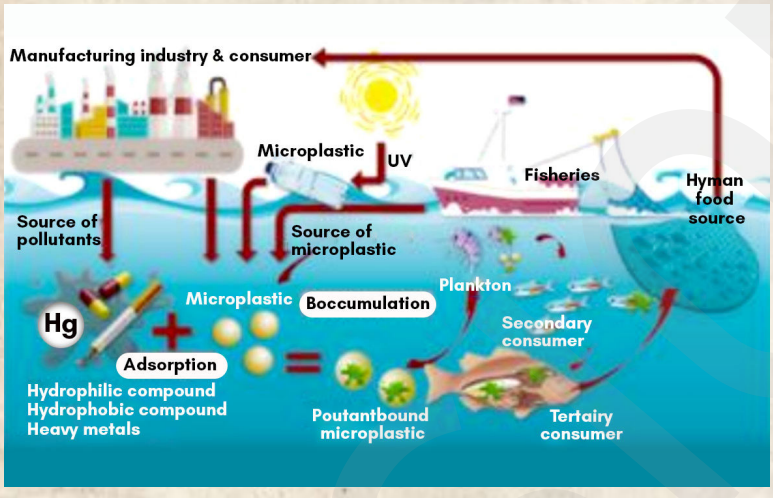
- India is a signatory to MARPOL (International Convention on Prevention of Marine Pollution).
- India does not have a distinct policy for Marine pollution and for tackling marine litter.
- Indian policy is restricted only to the banning of single use plastic.
- Prevention of Marine Pollution is dealt with by Merchant Shipping Rules, 2009 (under the Merchant Shipping Act, 1958), Environment (Protection) Act 1986, Air (Prevention and control of pollution) Act 1981 and rules made under CPCB.

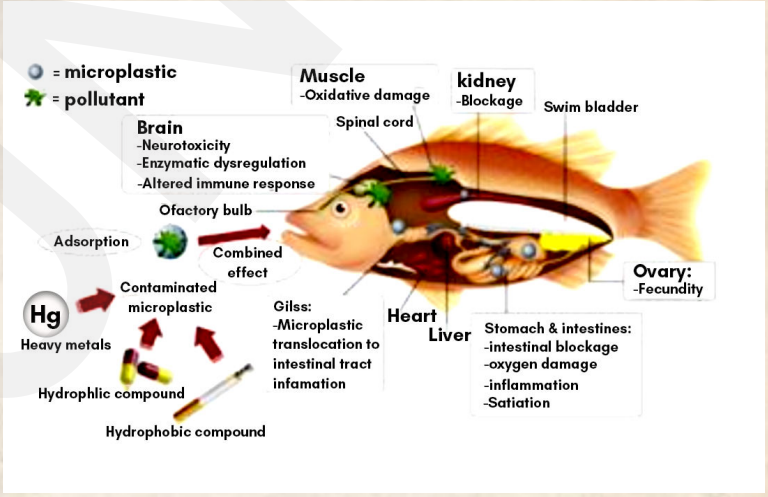
The Great Pacific Garbage Patch

The Great Pacific Garbage Patch is a collection of marine debris in the North Pacific Ocean. Also known as the Pacific trash vortex, the garbage patch is actually two distinct collections of debris bounded by the massive North Pacific Subtropical Gyre.

The Patch covers 1.6 million square kilometers area and is increasing continuously.







Thermal Pollution

Thermal Pollution
It is the degradation of water quality by any process that changes the ambient water temperature by 10–15 degrees.

Causes
Water discharged from:
Nuclear Power Plant Coal Fire Plants Industrial Effluents Hydro-electric Power

Effect
Increase in water temperature decreases dissolved oxygen in water Increases metabolism in fish Decline in swimming efficiency Disease resistance decreases
Aquatic plants and animals, especially warm tropical animals who live close to their upper limit of temperature.

Solution
Store the hot water in cooling ponds, allow the water to cool before releasing into any receiving water body

SOIL POLLUTION

POLLUTANTS	STATUS
Municipal Solid Waste:	■The urban India generates 62 million tonnes of municipal solid waste per annum. Only 43 million tonnes (MT) of the waste are collected, 11.9 MT is treated and 31 MT is dumped in landfill sites. ■Plastic bags made **from low density polyethylene (LDPE)** are virtually indestructible and ■Create colossal environmental hazard. ■Burning of solid waste release highly toxic and poisonous gases like carbon monoxide, ■Carbon dioxide, phosgene, dioxins and other poisonous chlorinated compounds.
Agricultural Waste:	■India is estimated to produce around 620 million tonne per annum of agricultural wastes, 43 per cent of which is animal dung and slaughter wastes.
Industrial hazardous waste:	■India produces approximately 51.1 MMT (million metric tonnes) of waste annually, with around 7.46 MMT of hazardous waste. Approximately 3.41 MMT (46%) is landfilled, 0.69 MMT (9%) is incinerated, and 3.35 MMT (45%) is recycled. Gujarat is the highest producer of hazardous wastes in India.
Bio-Medical waste:	■As per Assocham, the total quantity of medical waste generated in India is 550 tonnes per day (TPD) and by 2022, it is likely to increase to 775.5 TPD.
Electronic Waste:	■India generates about 1.85 million tonnes per annum of e-waste and ranks fifth in the world among top e-waste producing countries. It is projected that by 2020 the e waste generation in India will be 5.2 million tonnes per annum.

Control of Soil Pollution in India:

■Unlike water and air pollution, there is **no specific legislation in India that regulates land pollution.** In general, **land pollution is dealt under Environmental Protection Act,** which defines hazardous substances and confers the powers of making rules related to them upon the **Central government.**

■Acting on such powers, the Central government has brought Solid Waste Management Rules 2016, Hazardous and Other Wastes (Management& Transboundary Movement) Rules 2016, Plastic Waste Management Rules 2016, E-Waste (Management) Rule 2016 and Bio-Medical Waste Management Rules, 2018.

RADIOACTIVE POLLUTION

NUCLEAR WASTE AND ITS DISPOSAL

NUCLEAR POWER

435 NUCLEAR PLANTS WORLDWIDE
10,500 TONNES OF SPENT FUEL PER YEAR

As of 2019, nuclear power plants operate in 30 countries. Six countries have outright bans on use of nuclear reactors to generate electricity.

Operating nuclear power plants Ban in place

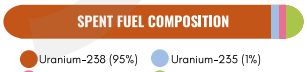
10% OF THE WORLD'S ELECTRICITY

Nuclear fuel releases many times more energy per gram than fossil fuels. Nuclear plants don't release carbon dioxide while they are operating.

WHAT IS NUCLEAR WASTE?

About 3% of spent nuclear fuel consists of radioactive fission products. In some countries, the spent fuel is reprocessed to separate the waste from uranium and plutonium.

SPENT FUEL COMPOSITION



Radioactive waste contains unstable isotopes of elements which decay and emit alpha, beta or gamma radiation. Eventually they decay into non-radioactive elements.

HALF LIVES: UP TO 32 YEARS
Cs-137 Sr-90 Cm-243 Cm-244 Co-60

HALF LIVES: 460-24,000 YEARS
Th-229 Pu-239 Pu-240 Am-241 Am-243

HALF LIVES:77,000-16,000,000 YEARS
Nb-94 I-129 Cs-135 Tc-99 Th-230 Np-237

As well as the radioactivity produced by nuclear waste, it also produces heat as isotopes decay. This poses issues for storage and disposal.

TYPES OF NUCLEAR WASTE

LOW LEVEL WASTE (LLW)
90% of all radioactive waste (by volume)
1% of the total radioactivity of all waste

LLW is defined as not exceeding 4 gigabecquerels pertonne (GBq/t) of alpha activity or 12 GBq/t of beta-gamma activity.

INTERMEDIATE LEVEL WASTE (ILW)
7% of all radioactive waste (by volume)
4% of the total radioactivity of all waste

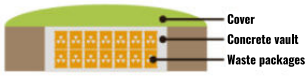
ILW produces more radiation than LLW, but doesn't generate as much heat as HLW. It includes metal fuel cladding.

HIGH LEVEL WASTE (HLW)
3% of all radioactive waste (by volume)
95% of the total radioactivity of all waste

HLW is defined as producing more than 2 kilowatts per metre cubed of heat due to its radioactivity. It requires shielding during transport and cooling before permanent disposal. It includes used fuel and separated waste.

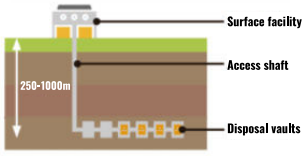
WASTE STORAGE & DISPOSAL

NEAR-SURFACE DISPOSAL



Low level waste's radioactivity is usually compacted into steel canisters and stored in concrete vaults underground. When full, vaults are sealed, covered and left. They ensure no significant radiation reaches the surface.

DEEP GEOLOGICAL DISPOSAL



Intermediate and high level waste generate heat and greater levels of radioactivity. Most countries plan to use deep geological disposal. The rock and soil acts as a barrier to the radiation. Before this, high level waste is incorporated into glass and stored for up to fifty years to allow heat to dissipate.

The Atomic Energy Regulatory Board (AERB) of India calls for reprocessing of the spent fuel and then disposing the waste to a repository. The repository must be located at:

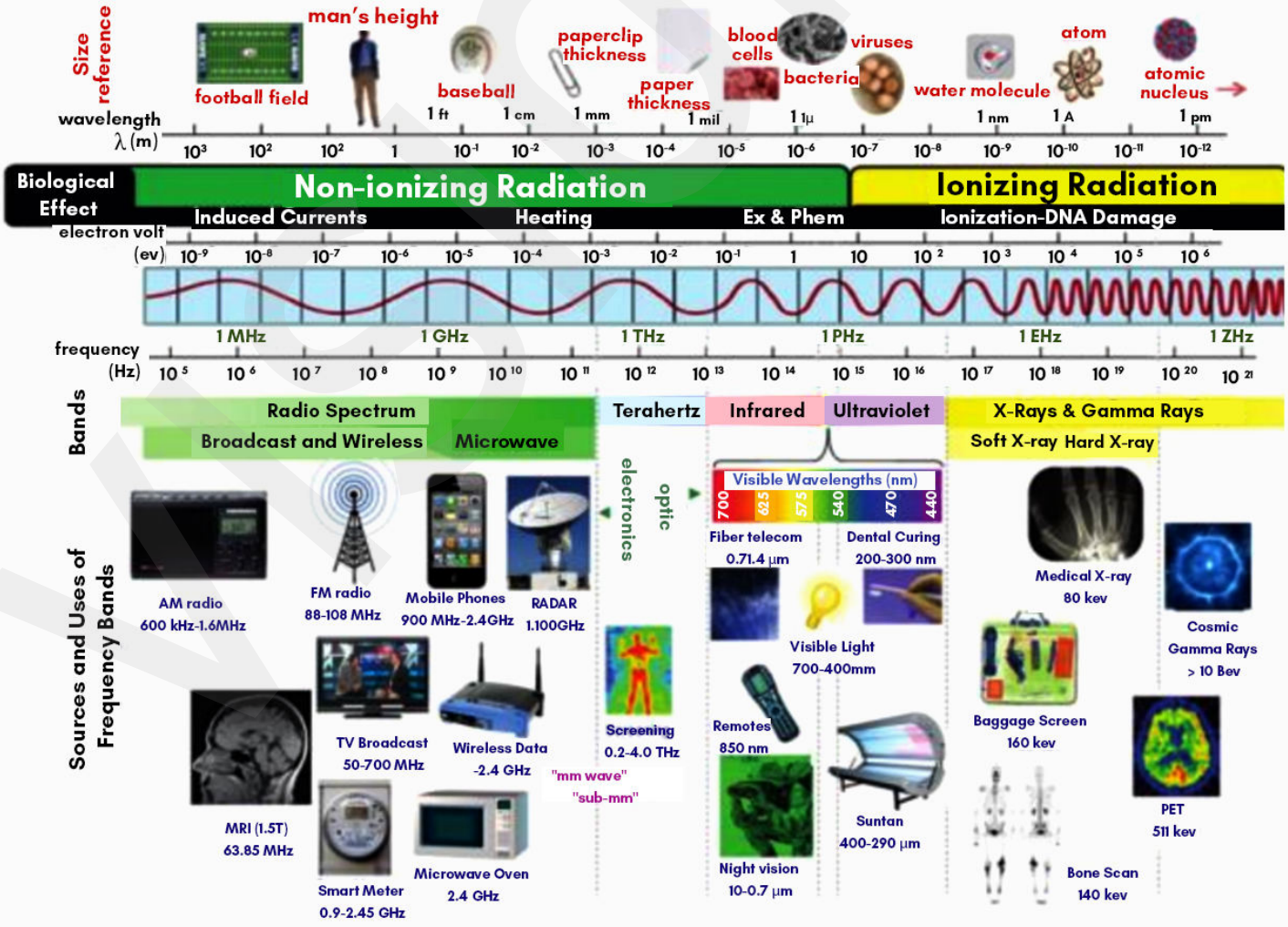
The Atomic Energy Regulatory Board (AERB) of India calls for reprocessing of the spent fuel and then disposing the waste to a repository. The repository must be located at:

- A remote place
- Where circulating ground water is absent and
- Has ability to contain radionuclides for geologically long periods of time.

The High-level radioactive wastes are managed in 3 stages:

- Immobilisation of high-level liquid waste into vitrified borosilicate glasses
- Storage of the vitrified waste for passive cooling & surveillance over a period of time, qualifying it for ultimate disposal.
- Ultimate storage/disposal of the vitrified waste in a deep geological repository (low permeable and mechanically stable rocks in between 250-1000m depth).

ELECTROMAGNETIC RADIATION SPECTRUM



Radiation is a form of energy travelling through space.

RADIATION

Non-ionizing radiations: They are constituted by the electromagnetic waves at the longer wavelength of the spectrum ranging from near infra-red rays to radio waves.

Ionizing radiations: Electromagnetic radiations such as short wavelength ultra violet radiations (UV), X-rays and gamma rays and energetic particles produced in nuclear processes, electrically charged particles like alpha and beta particles produced in radioactive decay and neutrons produced in nuclear fission, are highly damaging to living organisms

Levels of radiation exposure

The effects of radiation exposure at various doses:

- **6-7 5v (600-700 rem)** – a single dose is absolutely lethal
- **4.5 SV (450 rem)** – severe radiation sickness (kills 50% of people exposed)
- **1 Sv (100 rem)** – earliest stage of mild radiation sickness
- **0.75 Sv (75 rem)** – a short-term, insignificant change in blood content is caused by exposure at this level
- **0.3 SV (30 rem)** – exposure during a stomach x-ray
- **0.25 Sv (25 rem)** – acceptable one-time exposure of personnel
- **0.1 Sv (10 rem)** – accutable one-time exposure of the population
- **0.05 Sv (Srem** – acceptable exposure of nuclear power plant personnel in normal conditions over a year
- **0.03 Sv (3 rem)** – exposure during a dental X-ray
- **5 mSv (500 mrem)** – acceptable exposure of personnel under normal conditions
- **1 may (100 mrem)** – background radiation
- **10 mSv (1 mrem)** – flight over a distance of 2400 km
- **0.005 mSv (0.5 mrem)** – three hours of television viewing a day over a year

Radiation doses that can result in injury or death

Sievert (Sv) – a unit of equivalent radiation dose according to the SI system

1 Sv = 100 rem**

* The International System of Units

** Rem – a unit of equivalent dose for any from of nting radiaton

Common effects of short-term exposure

- **10,000 mSv (10 Sv) –** death within a few weeks
- **Between 2000 and 10000 mSv (2 - 10 Sv) –** acute and most likely fatal radiation sickness
- **1000 mSv (1 Sv) –** Normal background radiation is

Normal background radition is

3 mSv per year.

This comes from natural sources of ionizing radiation. Roughly two mSv per year come from radon in the air. These radiation levels are close to the minimum doses absorbed by all people on the planet

Normal background radition

0.3 -0.6 mSv / year – man-made, mostly medical sources of radiation

Backround radiation

Safety standards call for 0.05 mSv per vear around nuclear power plants The actual dose near nuclear facilities is much less

EMF Radiation norms in India

- India adopted the International Commission for Non-Ionizing Radiation Protection (ICNIRP) Guidelines in 2008.
- Based on the Recommendations of an Inter-Ministerial Committee constituted by DoT in the year 2010, the permissible limit of Electromagnetic Radiation from Mobile towers is reduced to 1/10th of the limit prescribed by the ICNIRP.
- India has adopted the most stringent SAR value of 1.6 Watt/Kg for mobile handsets. It has been made mandatory for all the mobile phones sold in India to display its SAR value.
- Indian Telegraph Act 1885 has been enacted for strict compliance.

International Conventions

Key Conventions	Information
STOCKHOLM declaration (1972)	1972, First declaration on environment
CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION (AIR Convention), 1979	1979, to reduce and prevent air pollution including long range transboundary air pollution.
Vienna Convention (1985)	Protect Ozone
Montreal Protocol (1987)	Phasing out Chlorofluorocarbons to protect Ozone layer. Kigali amendment in 2019 included Hydrofluorocarbon as well. Kigali Agreement - Amends Montreal Protocol to fight global warming. 80% reduction in HFC consumption by 2047.
Basel Convention (1989)	On transboundary movement of Hazardous wastes
FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC) 1992	Global warming Kyoto Protocol: CO2 + 6 other GHGS (Methane, Nitrous Oxide, Sulphur Hexafluoride, Hydrofluorocarbons and Perfluorocarbons)
Stockholm convention (2001)	On Persistent Organic Pollutant (POP) called Dirty Dozen, including eight organochlorine pesticides: aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex and toxaphene; two industrial chemicals:hexachlorobenzene (HCB) and the polychlorinated biphenyl (PCB) group; and two groups of industrial by-products: dioxins and furans.
Minamata convention (2013)	To protect health and environment from anthropogenic emissions/release of Mercury and its compounds.
UN-REDD	Reducing emissions from deforestation and forest degradation.
REDD +	Reducing emissions from deforestation and forest degradation + conservation and enhancement of forest carbon stocks and sustainable management of forests.
Rotterdam convention (1998)	Convention on Prior Informed Consent (PIC) procedure for certain hazardous chemicals and pesticides in international trade.